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Laboratory Report No. 1808
Date: July 10, 1995

PREPARED FOR: **Intermountain Power Service Corp.**
850 West Brush Wellman Road
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REFERENCE: **Intermountain Power Project -- Unit #2**
Analysis of Used Filter Bags -- After Fourteen Months of Sonic Horn Operation
Purchase Order No. 95-72657

BACKGROUND

Intermountain Power Service Corp. (IPSC) operates two GEESI reverse-gas fabric filters serving two identical 840 MW coal-fired boilers, Unit #1 and Unit #2. Each fabric filter consists of three separate casings with sixteen compartments per casing, each containing 396 filter bags, for a total of 19,008 bags per unit. The bags are 12.0" diameter by 32' 11-11/16" long (under 75 lbs. tension) with cap top, compression band bottom, and eight anti-collapse rings. They are fabricated from 13.5 oz/yd^2 glass fabric (warp face out) with Burlington Glass Fabrics' (now BGF Industries') I-625 acid-resistant finish.

It has been well-documented that different versions of I-625 finish were utilized for each of the two units, due to a change made by BGF in the interim. Unit #1 bag fabric was finished with the original I-625 finish which is light gray in color and yields a more supple fabric hand. Unit #2 bag fabric was finished with a revised I-625 finish which is darker brownish-gray in color and yields a somewhat stiffer fabric hand. These finishes are referred to hereinafter as "light" (Unit #1) and "dark" (Unit #2).

Startup (initial flue gas) and commercial operation dates for the two baghouses were as follows:

Unit #	Startup Date	Commercial Operation
1	3/28/86	June 1986
2	2/16/87	May - June 1987

Both units were retrofitted with sonic horns about eighteen months ago for the purpose of reducing the operating ΔP.

REQUEST and SAMPLE DESCRIPTION

A total of nine (9) bags, removed from Unit #2 in March 1995, were submitted for analysis to determine their condition after fourteen (14) months of sonic horn operation. Ring cover stitching failures, which had been experienced prior to the installation of the horns, had continued to occur during the horn operation. Mr. Jeff Payne of IPSC instructed GFTS to ignore any such failures when analyzing the bags.

The bags were received on April 19, 1995, and were marked on their shipping cartons and on the bag caps for identification, as follows:

Casing/Compartment No.	Bag/Thimble No.	Removal Date
A3	B-15	3/28/95
A9	H-12	3/28/95
A15	I-7	3/28/95
B4	E-11	3/29/95
B10	C-11	3/29/95
B15	O-12	3/29/95
C8	O-10	3/30/95
C11	P-18	3/30/95
C14	D-17	3/30/95

Since only one bag was removed from any one compartment, the bags are referred to by their compartment number in this report.

Based on a diagram of the sonic horn locations that was received from IPP, the three bags from Casing B and the bag from Compartment C8 were in close proximity to one of the horns. The other five bags were located a distance of "three to seven bags" from any one of the horns.

Assuming that these were original equipment bags, they had been "in service" for about 97 months.

SUMMARY and CONCLUSIONS

Comparison of these bags to those tested prior to the onset of sonic horn operation (GFTS Report No. 1473) reveals that **fourteen months of horn operation had not affected the physical strength or integrity of the filter bags in Unit #2**. The as-received permeability was about the same as after two months of horn operation, which is 15% higher than it was prior to horn operation. The vacuumed permeability, which has always averaged 20-23 cfm on bags from Unit #2, has been unaffected by horn operation. However, the effectiveness of the horns at reducing operating pressure drop (or filter drag) of the bags should not be based on used fabric permeability measured in the laboratory, but rather on an evaluation of actual pressure drop (vs. relative gas flow) measurements recorded before and after the onset of horn operations.

The bags in this set were not weighed by GFTS as had been customary, because we were informed by Mr. Jeff Payne that extensive "in situ" bag weighing is performed by IPSC and that the test bags are disturbed (shaken) to varying extents prior to and during removal. We have always stated that in situ bag weighing is the preferable method of evaluating residual dust mass.

Ignoring the ring cover stitching failures, the bags were in excellent physical condition. The average Mullen burst strength was the same as it had been after two months of horn operation, which is only 5% lower than it had been prior to the installation of the horns. Average MIT flex values have decreased by only about 7% during the fourteen months of horn operation. The Mullen burst strength and MIT flex values for all "dark" finished bags still exceeded the minimum values specified for new fabric, even after eight years of service! More importantly, there was no evidence of any localized fabric wear or degradation that could cause premature bag failures. There was no significant difference between the net Mullen burst strength measured on the reverse-gas collapse folds (620 lb/in^2 average for all bags) or away from them (639 lb/in^2).

Two of the bags, those from Compartments A3 and C14, were made of fabric with the "light" finish, as originally used for Unit #1. It is unknown whether these bags were installed in Unit #2 as original equipment or as subsequent replacement bags. However, the fabric from these bags differed substantially from the standard "dark" finished fabric in Unit #2 in the following respects: higher permeability (as-received), lower fill MIT flex, and lower Mullen burst. All data from these "light" bags were excluded from the averages that were used for Unit #2 bag comparisons, but separate averages are presented for the "light" bags.

A summary of the data obtained on the Unit #2 ("dark" finished) bags tested at various service intervals is presented in Table 1 and compared to the new fabric QC data.

Depending on the extent of their occurrence, it is possible that the ring cover stitching failures will be the limiting factor in determining the ultimate life of the bags. It is also possible that the ring cover failures, if they become too extensive, may reduce the life extension (of the current set of bags) that may have been achieved due to ΔP reduction resulting from the sonic horns. IPP has reported that sonic horn operation has had no apparent effect on the frequency of ring cover failures.

TABLE 1

INTERMOUNTAIN POWER UNIT #2
USED BAG/FABRIC PROPERTIES vs. LENGTH OF SERVICE
"DARK" (I-625G) FINISHED FABRIC

FABRIC/BAG PROPERTY	NEW FABRIC QC DATA (a)	USED BAG FABRIC				
Bag Removal Date	Not Applicable	1990 (b)	1991 (c)	1993 (d) Before Horns	1994 (e) 2 Mo. Horns	1995 14 Mo. Horns
Length of Service	" "	36 mo	48-53 mo	80 mo	85 mo	97 mo
Permeability (cfm/ft²):						
As Received -	" "	1.40	1.40	1.11	1.26	1.28
Vacuumed -	" "	20.7	19.9	22.8	21.5	22.5
Fabric pH	" "	11.24	11.43	10.72	11.07	10.97
Mullen Burst (psi)(f)	829	793	702	694	661	660
MIT Flex (cycles):						
Warp -	38,500	10,800	12,800	11,200	11,300	10,400
Fill -	10,300	3,990	3,780	3,160	3,410	2,950
Fabric Properties (Washed):						
Weight (oz/yd²) -	Not Reported	13.70	13.67	13.59	13.66	13.68
Permeability (cfm/ft²) -	45.7	52.8	55.0	64.7	59.8	63.0
Loss on Ignition (%) -	5.1	4.70	4.93	4.74	4.69	4.98

(a) "The Design, Start-Up and Operation of the Intermountain Power Project, Unit #2 Fabric Filter System"; R.L. Miller, et. al; Seventh Symposium on the Transfer and Utilization of Particulate Control Technology; Nashville, TN; 1988. (QC data are averages of the "low" and "high" values that were reported.)

(b) Laboratory Report No. 683; GFTS, Inc.; May 25, 1990. (Averages include one "dark" replacement bag operating in Unit #1, except for Mullen burst and MIT flex.)

(c) Laboratory Report No. 955; GFTS, Inc.; December 3, 1991. (Averages include one "dark" replacement bag operating in Unit #1, except for Mullen burst and MIT flex.)

(d) Laboratory Report No. 1473; GFTS, Inc.; April 28, 1994.

(e) Laboratory Report No. 1568; GFTS, Inc.; August 22, 1994.

(f) Used bag Mullen burst values are "net" (gross-tare; tare=50 psi). The Mullen burst values for new fabric were not specified whether "net" or "gross".

TEST DATA and OBSERVATIONS

Physical Condition of the Bags: All of the bags were in excellent physical condition with no signs of service-related wear, except for five (5) failed ring covers. The reverse-gas collapse folds were moderate to light in intensity, and no "ancillary lines" were present at the collapse folds in the top sections of the bags (as are sometimes observed on bags cleaned with sonic horns). No "accordion-type" creases were evident in the bottom sections, indicating that adequate bag tension had been maintained.

In general, the bags had a moderate-to-heavy residual cake of tan/gray colored ash inside, with no crust or nodulation. This cake was readily removed by vacuuming. The bag exteriors were somewhat dusty, but this could have resulted from contamination during removal, handling, and shipping.

Fabric Strength: Both the Mullen burst and MIT flex values were remarkably high for glass bags that have been in service for 97 months. This is undoubtedly due in part to the low baghouse operating temperature, 275°F outlet, and to the alkaline fly ash (used fabric pH = 11.0) which have moderated the effects of the flue gas on the acid-resistant finished glass fabric.

The average fabric strength (Mullen burst and MIT flex) has changed very little during the fourteen months of sonic horn operation. Refer to Tables 1 and 2 for comparison of the average strength of the current bags to that of new fabric and of previously tested used bags. Data on individual bags is presented in Table 3 for Mullen burst (top, middle, and bottom sections) and in Table 4 for MIT flex.

Note that the "light" finished fabric (Bags A3 and C14) had much lower Mullen burst and fill MIT values than the "dark" finished fabric that is the standard in Unit #2. These results generally correspond to previous comparisons of the two different finished fabrics at IPP.

Permeability and Bag Weight: Average permeability data is compared to that of previously tested used bags in Table 1. The as-received permeability was virtually the same as it had been on the bags tested after two months of sonic horn operation. Since the bags are subjected to much greater movement during removal, shipment, and sample preparation than they are during normal in-service cleaning, the actual in situ fabric permeability is always considerably less than that measured in the laboratory.

Vacuumed permeability values were in the 16-25 cfm range (except for bag C11 which had an unusually high value of 31.5 cfm), about the same as that of used bags from Unit #2 that have been previously tested. This vacuumed permeability range is indicative of "normal", minimal penetration of ash into the fabric structure.

Note that the "light" finished fabric (Bags A3 and C14) had a considerably higher permeability, as-received, than the "dark" finished fabric that is the standard in Unit #2. These results generally correspond to previous comparisons of the two different finished fabrics at IPP.

The permeability profiles (top, middle, and bottom) of each bag are presented in Table 5 (As Received) and Table 6 (Vacuumed). Bag lengths and fabric pH values are presented in Table 7.

Fabric Construction and Properties: A washed sample of fabric from the middle of each bag was analyzed for construction, L.O.I., and permeability. This data is summarized and compared to original QC data and to the specification in Table 2, and presented for each individual bag in Table 8. All bag fabrics met the count and weight specifications. All fabric L.O.I. values were within the range reported for new fabric of the same finish type. Average permeability values were 38% higher than the range reported for new fabric, but this is not abnormal considering the handling that the fabric experiences during bag fabrication, packing, installation, in-service use, removal, and washing (though performed carefully).

Raw Data: The MIT flex data sheets are presented in the Appendix. Raw data for permeability and Mullen burst testing is on file at GFTS, and it is available upon request.

TABLE 2

INTERMOUNTAIN POWER UNIT #2 - USED BAGS REMOVED MARCH 1995
AFTER FOURTEEN MONTHS OF SONIC HORN OPERATION
AVERAGE FABRIC PROPERTIES vs. NEW FABRIC QC DATA
(Testing performed on washed samples, except Mullen and MIT on vacuumed samples)

"DARK" (I-625 G) FINISHED FABRIC ONLY

FABRIC PROPERTY	SPECIFICATION	QC DATA MIN	QC DATA MAX	USED BAG DATA AVG	USED BAG DATA MIN	USED BAG DATA MAX	% CHANGE*
Loss On Ignition: (%)	4.0 min	4.6	5.6	4.98	4.67	5.24	- 2%
Permeability: (cfm/ft^2)	35-55	41.8	49.6	63.0	57.8	70.4	+ 38%
Mullen Burst: (psi**)	550 min	757	901	660	602	721	- 20%
MIT Flex (cycles):							
Warp -	8,000 min	36,000	41,000	10,400	9,080	12,500	- 73%
Fill -	2,000 min	9,639	10,905	2,950	2,300	3,880	- 71%
Weight: (oz/yd^2)	13.5 $\pm$ 5%	Not Reported		13.68	13.40	14.05	N/A
Count (per inch):							
Warp -	44 $\pm$ 2	Not Reported		43	43	43	N/A
Fill -	24 $\pm$ 2	Not Reported		24	24	24	N/A

All used bag fabric samples had a 3x1 Twill (left hand) weave, ECDE 37 1/0 warp yarns, and ECDE 75 1/3 (2 texturized and 1 filament) fill yarns, as specified.

* % Change compared to the average of the minimum and maximum QC values. Mean QC data were not reported.

** Used bag Mullen Burst values are "net" (gross-tare; where tare = 50 psi). The specification and QC Mullen Burst values were not specified whether "net" or "gross".

TABLE 3

INTERMOUNTAIN POWER UNIT #2 - USED BAGS REMOVED MARCH 1995
AFTER FOURTEEN MONTHS OF SONIC HORN OPERATION
MULLEN BURST PROFILE (psi, net)

COMPARTMENT	BAG SECTION			BAG AVERAGE
	TOP	MIDDLE	BOTTOM	
A3*	595	522	548	555
A9	642	592	665	633
A15	665	693	683	680
B4	602	605	600	602
B10	627	668	615	637
B15	675	653	727	685
C8	677	673	643	664
C11	753	708	702	721
C14*	508	537	463	503
OVERALL AVERAGES				
"Dark" Fabric	663	656	662	660
"Light" Fabric	552	530	506	529

* "Light" finished fabric

The value for each bag section is an average of 3 tests. Testing was performed on vacuumed samples.

TABLE 4

INTERMOUNTAIN POWER UNIT #2 - USED BAGS REMOVED MARCH 1995
AFTER FOURTEEN MONTHS OF SONIC HORN OPERATION
MIT FLEX DATA (cycles to failure)

COMPARTMENT	WARP	FILL
A3*	8,380	1,480
A9	11,000	2,300
A15	9,920	3,160
B4	9,530	2,480
B10	9,090	2,880
B15	11,400	2,960
C8	9,150	3,030
C11	12,500	3,880
C14*	9,560	2,000
OVERALL AVERAGES		
"Dark" Fabric	10,400	2,950
"Light" Fabric	8,970	1,740

* "Light" finished fabric

Each warp MIT value is an average of 3 specimens tested, and each fill is an average of 6 specimens tested. Testing was performed on vacuumed middle sections using an 0.03" head, 4 lb weight, and #8 spring. Values were corrected to 55% RH, using the attached formula, and rounded to three significant figures.

TABLE 5

INTERMOUNTAIN POWER UNIT #2 - USED BAGS REMOVED MARCH 1995
AFTER FOURTEEN MONTHS OF SONIC HORN OPERATION
"AS RECEIVED" PERMEABILITY PROFILE (cfm/ft² @ 0.5 WG)

COMPARTMENT	BAG SECTION			BAG AVERAGE
	TOP	MIDDLE	BOTTOM	
A3*	1.58	1.41	1.58	1.52
A9	1.14	1.38	1.59	1.37
A15	1.02	1.03	1.69	1.25
B4	1.06	1.04	1.08	1.06
B10	1.13	1.06	1.28	1.16
B15	1.30	1.13	1.33	1.25
C8	1.40	1.27	1.55	1.41
C11	1.34	1.65	1.49	1.49
C14*	2.07	1.87	2.10	2.01
OVERALL AVERAGES				
"Dark" Fabric	1.20	1.22	1.43	1.28
"Light" Fabric	1.82	1.64	1.84	1.77

* "Light" finished fabric

The value for each bag section is an average of 3 tests.

TABLE 6

INTERMOUNTAIN POWER UNIT #2 - USED BAGS REMOVED MARCH 1995
AFTER FOURTEEN MONTHS OF SONIC HORN OPERATION
VACUUMED PERMEABILITY PROFILE (cfm/ft² @ 0.5" WG)

COMPARTMENT	BAG SECTION			BAG AVERAGE
	TOP	MIDDLE	BOTTOM	
A3*	27.1	20.3	25.0	24.1
A9	24.7	27.6	24.7	25.7
A15	24.0	22.6	24.4	23.7
B4	20.1	17.7	17.6	18.5
B10	15.9	17.5	13.3	15.6
B15	22.9	23.9	23.9	23.6
C8	21.2	18.6	17.5	19.1
C11	33.5	30.0	30.9	31.5
C14*	19.5	20.5	18.8	19.6
OVERALL AVERAGES				
"Dark" Fabric	23.2	22.6	21.8	22.5
"Light" Fabric	23.3	20.4	21.9	21.8

* "Light" finished fabric

The value for each bag section is an average of 3 tests.

TABLE 7

INTERMOUNTAIN POWER UNIT #1 - USED BAGS REMOVED MARCH 1995
AFTER FOURTEEN MONTHS OF SONIC HORN OPERATION
MISCELLANEOUS TEST DATA

COMPARTMENT	BAG LENGTH*	FABRIC pH **
A3***	32' 10-1/2"	------
A9	32' 10-3/4"	10.94
A15	32' 11-1/2"	------
B4	32' 11"	------
B10	32' 11-1/4"	10.78
B15	33' 0"	------
C8	32' 10-3/4"	------
C11	32' 10-3/4"	11.18
C14***	32' 10-1/2"	------
OVERALL AVERAGES		
"Dark" Fabric	32' 11-1/4"	10.97
"Light" Fabric	32' 10-1/2"	------

* Measured at the seam under firm hand tension

** 5 g as-received fabric per 100 ml distilled water

*** "Light" finished fabric

TABLE 8

INTERMOUNTAIN POWER UNIT #2 - USED BAGS REMOVED MARCH 1995
AFTER FOURTEEN MONTHS OF SONIC HORN OPERATION
FABRIC PROPERTIES - WASHED SAMPLES

COMPARTMENT	WEIGHT (oz/yd^2)	PERMEABILITY (cfm/ft^2)	L.O.I. (%)
A3*	13.77	55.6	5.73
A9	13.40	63.6	4.67
A15	13.58	70.4	5.17
B4	13.71	59.5	4.94
B10	13.59	57.8	4.89
B15	13.72	60.8	5.24
C8	14.05	61.6	4.85
C11	13.70	67.1	5.10
C14*	13.69	55.5	5.07
OVERALL AVERAGES			
"Dark" Fabric	13.68	63.0	4.98
"Light" Fabric	13.73	55.6	5.40

All samples had the same weave, count, and nominal yarns sizes, as follows:

Weave:	3x1 Left-Hand Twill
Count (Warp x Fill):	43x24 per inch
Warp Yarns:	ECDE 37 1/0
Fill Yarns:	ECDE 75 1/3 (2 texturized + 1 filament)

* "Light" finished fabric

APPENDIX

MIT Flex Data Sheets

Grubb Filtration Testing Services, Inc. — M.I.T. Flex Data Sheet

Date Prepared: 7/2/95 — Sample #: 1808-A-3

Fabric Style: 13.5 oz AR — Head Jaw: 0.03"/4 lb/#8

Sample Condition: Used bag - vacuumed middle

WARP

Specimen	Test Humidity	Raw Flex	Corrected To 55%
#1	57.3	7124	7708
#2	56.8	8511	9049
#3	56.3	8015	8373
#4			
#5			
#6			
#7			
#8			
#9			
#10			
Mean:		7,883	8,377
Standard Deviation:		703	671
Variance:		0.09	0.08
# of Specimens:		3	

FILL

Specimen	Test Humidity	Raw Flex	Corrected To 55%
#1	60.0	1063	1266
#2	60.0	1039	1238
#3	59.5	1127	1319
#4	59.5	1211	1418
#5	59.0	1581	1819
#6	58.5	1601	1810
#7			
#8			
#9			
#10			
Mean:		1,270	1,478
Standard Deviation:		256	268
Variance:		0.20	0.18
# of Specimens:		6	

Correction Formula: ln Flex[55%] = ln Flex[Raw] + ((Test Humidity - 55) x 0.035)

Grubb Filtration Testing Services, Inc. — M.I.T. Flex Data Sheet

Date Prepared: 7/2/95 — Sample #: 1808-A-9

Fabric Style: 13.5 oz AR — Head Jaw: 0.03"/4 lb/#8

Sample Condition: Used bag - vacuumed middle

WARP

Specimen	Test Humidity	Raw Flex	Corrected To 55%
#1	60.5	8258	10011
#2	60.0	9301	11080
#3	57.0	11139	11947
#4			
#5			
#6			
#7			
#8			
#9			
#10			
Mean:		9,566	11,013
Standard Deviation:		1,459	970
Variance:		0.15	0.09
# of Specimens:		3	

FILL

Specimen	Test Humidity	Raw Flex	Corrected To 55%
#1	60.0	1422	1694
#2	60.5	2291	2777
#3	60.5	1582	1918
#4	60.5	2212	2682
#5	60.0	2676	3188
#6	60.0	1271	1514
#7			
#8			
#9			
#10			
Mean:		1,909	2,296
Standard Deviation:		562	677
Variance:		0.29	0.30
# of Specimens:		6	

Correction Formula: ln Flex[55%] = ln Flex[Raw] + ((Test Humidity - 55) x 0.035)

Grubb Filtration Testing Services, Inc.

M.I.T. Flex Data Sheet

Date Prepared: 7/2/95

Sample #: 1808-A-15

Fabric Style: 13.5 oz AR

Head Jaw: 0.03"/4 lb/#8

Sample Condition: Used bag - vacuumed middle

WARP

Specimen	Test Humidity	Raw Flex	Corrected To 55%
#1	56.0	8580	8886
#2	56.0	11551	11962
#3	56.0	8603	8909
#4			
#5			
#6			
#7			
#8			
#9			
#10			
Mean:		9,578	9,919
Standard Deviation:		1,709	1,769
Variance:		0.18	0.18
# of Specimens:		3	

FILL

Specimen	Test Humidity	Raw Flex	Corrected To 55%
#1	58.0	2979	3309
#2	58.0	2054	2281
#3	57.5	2710	2958
#4	57.5	3755	4098
#5	61.0	2549	3145
#6			
#7			
#8			
#9			
#10			
Mean:		2,809	3,158
Standard Deviation:		627	655
Variance:		0.22	0.21
# of Specimens:		5	

Correction Formula: ln Flex[55%] = ln Flex[Raw] + ((Test Humidity - 55) x 0.035)

Grubb Filtration Testing Services, Inc. — M.I.T. Flex Data Sheet

Date Prepared: 7/2/95 — Sample #: 1808-B-4

Fabric Style: 13.5 oz AR — Head Jaw: 0.03"/4 lb/#8

Sample Condition: Used bag - vacuumed middle

WARP

Specimen	Test Humidity	Raw Flex	Corrected To 55%
#1	55.5	7435	7566
#2	55.5	9170	9332
#3	55.8	11388	11691
#4			
#5			
#6			
#7			
#8			
#9			
#10			
Mean:		9,331	9,530
Standard Deviation:		1,981	2,070
Variance:		0.21	0.22
# of Specimens:		3	

FILL

Specimen	Test Humidity	Raw Flex	Corrected To 55%
#1	61.0	1904	2349
#2	61.5	2304	2893
#3	61.5	2457	3085
#4	61.0	1933	2385
#5	60.5	1773	2149
#6	60.0	1704	2030
#7			
#8			
#9			
#10			
Mean:		2,013	2,482
Standard Deviation:		301	418
Variance:		0.15	0.17
# of Specimens:		6	

Correction Formula: ln Flex[55%] = ln Flex[Raw] + ((Test Humidity - 55) x 0.035)

Grubb Filtration Testing Services, Inc. — M.I.T. Flex Data Sheet

Date Prepared: 7/2/95 — Sample #: 1808-B-10

Fabric Style: 13.5 oz AR — Head Jaw: 0.03"/4 lb/#8

Sample Condition: Used bag - vacuumed middle

WARP

Specimen	Test Humidity	Raw Flex	Corrected To 55%
#1	57.5	7718	8424
#2	56.8	11793	12538
#3	56.0	6093	6310
#4			
#5			
#6			
#7			
#8			
#9			
#10			
Mean:		8,535	9,091
Standard Deviation:		2,936	3,167
Variance:		0.34	0.35
# of Specimens:		3	

FILL

Specimen	Test Humidity	Raw Flex	Corrected To 55%
#1	59.5	2161	2530
#2	58.5	3199	3616
#3	58.0	2448	2719
#4	56.5	2425	2556
#5	56.5	2951	3110
#6	56.5	2627	2769
#7			
#8			
#9			
#10			
Mean:		2,635	2,883
Standard Deviation:		380	415
Variance:		0.14	0.14
# of Specimens:		6	

Correction Formula: ln Flex[55%] = ln Flex[Raw] + ((Test Humidity - 55) x 0.035)

Grubb Filtration Testing Services, Inc. — M.I.T. Flex Data Sheet

Date Prepared: 7/2/95 — Sample #: 1808-B-15

Fabric Style: 13.5 oz AR — Head Jaw: 0.03"/4 lb/#8

Sample Condition: Used bag - vacuumed middle

WARP

Specimen	Test Humidity	Raw Flex	Corrected To 55%
#1	56.5	10744	11323
#2	57.0	13249	14210
#3	57.0	7999	8579
#4			
#5			
#6			
#7			
#8			
#9			
#10			
Mean:		10,664	11,371
Standard Deviation:		2,626	2,816
Variance:		0.25	0.25
# of Specimens:		3	

FILL

Specimen	Test Humidity	Raw Flex	Corrected To 55%
#1	56.5	2913	3070
#2	56.5	3772	3975
#3	56.5	1779	1875
#4	56.5	2462	2595
#5	56.3	3599	3760
#6	56.0	2389	2474
#7			
#8			
#9			
#10			
Mean:		2,819	2,958
Standard Deviation:		764	804
Variance:		0.27	0.27
# of Specimens:		6	

Correction Formula: ln Flex[55%] = ln Flex[Raw] + ((Test Humidity - 55) x 0.035)

Grubb Filtration Testing Services, Inc.

M.I.T. Flex Data Sheet

Date Prepared: 7/2/95

Sample #: 1808-C-8

Fabric Style: 13.5 oz AR

Head Jaw: 0.03"/4 lb/#8

Sample Condition: Used bag - vacuumed middle

WARP

Specimen	Test Humidity	Raw Flex	Corrected To 55%
#1	56.0	7899	8180
#2	56.5	8613	9077
#3	56.0	9827	10177
#4			
#5			
#6			
#7			
#8			
#9			
#10			
Mean:		8,780	9,145
Standard Deviation:		975	1,000
Variance:		0.11	0.11
# of Specimens:		3	

FILL

Specimen	Test Humidity	Raw Flex	Corrected To 55%
#1	56.0	3244	3360
#2	56.5	2322	2447
#3	56.5	3180	3351
#4	56.0	3108	3219
#5	59.0	2196	2526
#6	57.5	2977	3249
#7			
#8			
#9			
#10			
Mean:		2,838	3,025
Standard Deviation:		459	422
Variance:		0.16	0.14
# of Specimens:		6	

Correction Formula: ln Flex[55%] = ln Flex[Raw] + ((Test Humidity - 55) x 0.035)

Grubb Filtration Testing Services, Inc. — M.I.T. Flex Data Sheet

Date Prepared: 7/2/95 **Sample #:** 1808-C-11

Fabric Style: 13.5 oz AR **Head Jaw:** 0.03"/4 lb/#8

Sample Condition: Used bag - vacuumed middle

WARP

Specimen	Test Humidity	Raw Flex	Corrected To 55%
#1	57.0	10525	11288
#2	57.5	12557	13705
#3	57.0	11530	12366
#4			
#5			
#6			
#7			
#8			
#9			
#10			
Mean:		11,537	12,453
Standard Deviation:		1,016	1,211
Variance:		0.09	0.10
# of Specimens:		3	

FILL

Specimen	Test Humidity	Raw Flex	Corrected To 55%
#1	57.0	4129	4428
#2	57.8	4143	4562
#3	57.0	4260	4569
#4	57.0	2197	2356
#5	57.3	4010	4339
#6	57.5	2780	3034
#7			
#8			
#9			
#10			
Mean:		3,587	3,881
Standard Deviation:		874	948
Variance:		0.24	0.24
# of Specimens:		6	

Correction Formula: ln Flex[55%] = ln Flex[Raw] + ((Test Humidity - 55) x 0.035)

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Grubb Filtration Testing Services, Inc. — M.I.T. Flex Data Sheet

Date Prepared: 7/2/95 — Sample #: 1808-C-14

Fabric Style: 13.5 oz AR — Head Jaw: 0.03"/4 lb/#8

Sample Condition: Used bag - vacuumed middle

WARP

Specimen	Test Humidity	Raw Flex	Corrected To 55%
#1	56.0	10659	11039
#2	57.0	9934	10654
#3	56.0	6755	6996
#4			
#5			
#6			
#7			
#8			
#9			
#10			
Mean:		9,116	9,563
Standard Deviation:		2,077	2,231
Variance:		0.23	0.23
# of Specimens:		3	

FILL

Specimen	Test Humidity	Raw Flex	Corrected To 55%
#1	57.5	1376	1502
#2	57.5	1949	2127
#3	57.5	2484	2711
#4	57.5	1232	1345
#5	57.5	1564	1707
#6	57.5	2405	2625
#7			
#8			
#9			
#10			
Mean:		1,835	2,003
Standard Deviation:		530	579
Variance:		0.29	0.29
# of Specimens:		6	

Correction Formula: ln Flex[55%] = ln Flex[Raw] + ((Test Humidity - 55) x 0.035)